

CLAIMS

1. A plasma film forming apparatus for forming a film on a surface of a base material under the effect of plasma, comprising:

- (A) a first gas supplying source containing a raw material of said film;
- (B) a second gas supplying source caused by plasma discharge to reach an excited state but containing no component capable of being formed into the form of film; and
- (C) a processing head which is to be placed opposite said base material;

said processing head being provided with:

- (a) a grounded ground electrode; and
- (b) an electric field impressing electrode connected to an electric power source and forming a plasma discharge space between said ground electrode and said electric field impressing electrode;

said processing head being formed with:

- (c) a first flow passage for introducing a first gas from said first gas supplying source to said base material in such a manner as to avoid or pass very near said plasma discharge space; and
- (d) a second flow passage including said plasma discharge space and for causing a second gas coming from said second gas supplying source to contact said first gas after allowing said second gas to pass through said plasma discharge space.

2. A plasma film forming apparatus according to claim 1, wherein said first and second flow passages are converged with each other and continuous with a common blowoff passage which is open to a surface of said processing head which surface is to be placed opposite said base material.

3. A plasma film forming apparatus according to claim 2, wherein one of said first and second flow passages is linearly continuous with said common blowoff passage, and the other is crossed with said one flow passage at an angle.
4. A plasma film forming apparatus according to claim 1, wherein downstream ends of said first and second flow passages are spacedly open to a surface of said processing head which surface is to be placed opposite said base material, and said open ends serve as a blowoff port for the first gas and as a blowoff port for the second gas, respectively.
5. A plasma film forming apparatus according to claim 1, wherein said processing head is provided with two electrodes which have the same polarities and which are arranged in mutually adjacent relation.
6. A plasma film forming apparatus according to claim 1, wherein said processing head is provided with two each of said electric field impressing electrodes and ground electrodes, said two electric field impressing electrodes are arranged in mutually adjacent relation thus forming said first flow passage therebetween, and said two each electric field impressing electrodes are placed opposite said two each corresponding ground electrodes thus forming said plasma discharge space therebetween.
7. A plasma film forming apparatus according to claim 6, wherein said four electrodes are arranged in the order of the ground electrode, the electric field impressing electrode, the electric field impressing electrode and the ground electrode, and owing to this arrangement, said two plasma discharge spaces and thus the second flow passages are arranged on both sides with said single first flow passage sandwiched therebetween.

8. A plasma film forming apparatus according to claim 7, wherein said processing head includes a base material opposing member which is to cover a surface to be faced with said base material of said electrode, and said base material opposing member formed with respective blowoff passages of said three flow passages.

9. A plasma film forming apparatus according to claim 7, wherein said processing head includes a base material opposing member which is to cover a surface to be faced with said base material of said electrode, a communication passage is formed as a part of said second flow passage between said base material opposing member and each electric field impressing electrode, said plasma discharge space and said first flow passage is communicated with each other through said communication passage, and said base material opposing member is formed with a common blowoff passage of said first and second gases such that said common blowoff passage is continuous with a crossing part between said first flow passage and said communication passage.

10. A plasma film forming apparatus according to claim 1, wherein said processing head is provided with a plurality of electric field impressing electrodes and a plurality of ground electrodes, and said electrodes are arranged in parallel relation such that first flow passages each formed between said electrodes having the same polarities and plasma discharge spaces, i.e., second flow passages each formed between said electrodes having different polarity are alternately arranged.

11. A plasma film forming apparatus according to claim 10, wherein said electrodes located at opposite end parts in the arrangement direction are ground electrodes.

12. A plasma film forming apparatus according to claim 1, wherein said electric field impressing electrode and said ground electrode extend in a direction orthogonal to the opposing direction of said electric field impressing electrode and said ground electrode, an upstream end of said plasma discharge space between said electrodes is disposed at one end part in a first direction orthogonal to said opposing direction and extending direction, and a downstream end thereof is disposed at the other end part in said first direction.

13. A plasma film forming apparatus according to claim 12, wherein an electricity feed line to said electric field impressing means is connected to one end part in the longitudinal direction of said electric field impressing electrode, and a ground line is connected to the other end part in the longitudinal direction of said ground electrode.

14. A plasma film forming apparatus according to claim 1, wherein said ground electrode is arranged in opposing relation on the side of said electric field impressing electrode which is to be faced with said base material in said processing head.

15. A plasma film forming apparatus according to claim 14, wherein said processing head includes a base material opposing member which is to cover a surface to be faced with said base material of said electric field impressing electrode, and said ground electrode is disposed at said base material opposing member.

16. A plasma film forming apparatus according to claim 15, wherein a gap is formed between said electric field impressing electrode and said base material opposing member, and said gap serves as a second flow

passage including said plasma discharge space.

17. A plasma film forming apparatus according to claim 16, wherein said plasma discharge space is directly crossed with said first flow passage, and said base material opposing member is formed with a common blowoff passage of said first and second gases such that said common blowoff passage is continuous with said crossing part.

18. A plasma film forming apparatus according to claim 15, wherein said base material opposing member is composed of ceramic, a surface thereof which is to be faced with said base material, i.e., a surface on the reverse side where said electric field impressing electrode is located is formed with a recess for receiving therein said ground electrode, and a forming part of said receiving recess is provided as a solid dielectric layer which is to cover a metal main body of said ground electrode.

19. A plasma film forming apparatus according to claim 17, wherein an end face to be faced with said common blowoff passage of a metal main body of said electric field impressing electrode is generally flush with or more expanded than an end face on the same side of the metal main body of said electric field impressing electrode.

20. A plasma film forming apparatus according to claim 17, wherein an end face on the side facing with said common blowoff passage of the metal main body of said ground electrode is more retracted than an end face on the same side of the metal main body of said electric field impressing electrode.

21. A plasma film forming apparatus according to claim 1, wherein said processing head is provided with a grounded conductive member such

that said grounded conductive member covers a side to be faced with said base material of said electric field impressing electrode.

22. A plasma film forming apparatus according to claim 21, wherein said conductive member forms a plasma discharge space between said electric field impressing electrode and said conductive member, and said conductive member is provided as said ground electrode.

23. A plasma film forming apparatus according to claim 21, wherein an insulative member for insulating said conductive member and said electric field impressing electrode is filled between said insulative member and said electric field impressing electrode.

24. A plasma film forming apparatus according to claim 1, wherein said processing head is provided with an intake duct having an intake port surrounding a peripheral edge part of a base material opposing surface thereof.

25. A plasma film forming apparatus for forming a film on a surface of a base material under the effect of plasma, comprising:

- a first gas supplying source containing a raw material of said film;

- a second gas supplying source caused by plasma discharge to reach an excited state but containing no component for capable of being formed into the form of film;

- a grounded ground electrode;

- an electric field impressing electrode connected to an electric power source and forming a plasma discharge space in such a manner as to oppose said ground electrode;

- a first flow passage forming means for flowing therethrough a first gas from said first gas supplying source in such a manner as to avoid or

pass very near said plasma discharge space and blowing said first gas to said base material; and

a second flow passage forming means for allowing a second gas coming from said second gas to pass through said plasma discharge space and causing said second gas to contact said first gas.

26. A plasma film forming apparatus according to claim 25, wherein said electric field impressing electrode includes a surface forming a first flow passage and provided as said first flow passage forming means.

27. A plasma film forming apparatus according to claim 25, wherein said electric field impressing electrode and said ground electrode are provided as said second flow passage forming means, in which a second flow passage and thus, a plasma discharge space are formed between said electric field impressing electrode and said ground electrode.

28. A plasma film forming apparatus according to claim 25, wherein said ground electrode is arranged on the side to be faced with said base member of said electric field impressing electrode with a dielectric member sandwiched between said ground electrode and said electric field impressing electrode, and a cutout for allowing said dielectric member to be exposed therethrough is formed in a part of said ground electrode, the inside of said cutout part serves as said plasma discharge space;

said second flow passage forming means makes said second gas blow out along said ground electrode and enter said cutout; and

said first flow passage forming means makes said first gas blow out on the reverse side to said ground electrode from said second gas in such a manner as to form a laminar flow with said second gas.

29. A plasma film forming apparatus according to claim 1, wherein

said electrode comprises a main body composed of metal, and a dielectric case composed of a solid dielectric member for receiving therein said main body.

30. A plasma film forming apparatus according to claim 29, wherein said dielectric case includes a case main body retractably receiving said electric main body in an internal space whose one surface is open, and a lid for blocking said opening.

31. A plasma film forming apparatus according to claim 29, wherein said plasma discharge space of said second flow passage is formed between said dielectric case of said electric field impressing electrode and said dielectric case of said ground electrode.

32. A plasma film forming apparatus according to claim 7, wherein each of said electrodes having same polarities comprises a main body composed of metal and a dielectric case composed of a solid dielectric member for receiving therein said main body, said dielectric cases of said electrodes are placed opposite each other, thereby forming said first flow passage therebetween.

33. A plasma film forming apparatus according to claim 29 or 32, wherein said dielectric cases of said electrodes are separately formed.

34. A plasma film forming apparatus according to claim 29 or 32, wherein said dielectric cases of said electrodes are integrally connected to one another.

35. A plasma film forming apparatus according to claim 29, wherein each electrode and thus the dielectric case thereof extend in a direction

orthogonal to the opposing direction with respect to the other electrode, and said dielectric case integrally includes a gas uniformizing part for uniformly dispersing gas, which is introduced into a flow passage between said dielectric case and the other electrode, in the extending direction.

36. A plasma film forming apparatus according to claim 29, wherein the thickness of a plate part on the side forming the plasma discharge space in said dielectric case is different between the upstream side and the downstream side of said plasma discharge space.

37. A plasma film forming apparatus according to claim 34, wherein said integral dielectric case is formed with a second flow passage serving as said plasma discharge space, a metal main body is received in each side of said integral dielectric case with said flow passage sandwiched therebetween, and a distance between said metal main bodies is different between the upstream side and the downstream side of said plasma discharge space.

38. A plasma film forming apparatus according to claim 1, further comprising a pin for impressing an electric field to said electrode or for being grounded, said pin including a conductive pin main body having a pin hole opening to a tip end face thereof and withdrawably embedded in said electrode, a core member electrically connected with said pin main body and slideably received in said pin hole, and a spring received in said pin hole and for biasing said core member so as to be pushed out of the tip end opening of said pin hole.

39. A plasma film forming apparatus according to claim 1, wherein a conductor hole is formed in said electrode, an electric field impressing or grounding covered conductor is inserted in said conductor hole, said

covered conductor is formed by covering a conducting wire with an insulative material, only a tip part of said wire located on an inner side of said hole is exposed from the insulative material, a screw is screwed in said electrode in such a manner as to be generally orthogonal to said conductor hole, and said screw presses the exposed tip part of said wire against an inner peripheral surface of said conductor hole.

40. A plasma film forming apparatus according to claim 1, wherein said processing head removably includes a base material opposing member formed with a first and a second gas blowoff passage and disposed opposite said base material.

41. A plasma film forming apparatus according to claim 40, further comprising support means for supporting said base material opposing member in such a manner as to place a peripheral edge part of said base material opposing member thereon with a surface to be faced with said base material of said base material opposing member directing downward;
an upper side part from said base material opposing member of said processing head is integrally placed on said base material opposing member.

42. A plasma film forming apparatus according to claim 41, wherein said support means has a frame-like configuration so that said processing head can be receiving therein in such manner as to be able to be removed upward, and an inner flange for hooking on a peripheral edge part of said base material opposing member is disposed at an inner peripheral edge of a lower end part of said support means.

43. A plasma film forming apparatus according to claim 42, wherein a positioning protrusion is disposed at one of said upper side part from said

base material opposing member of said processing head and said support means, and a positioning recess for allowing said positioning protrusion to be vertically fitted thereto is disposed at the other of said upper side part from said base material opposing member of said processing head and said support means.

44. A plasma film forming apparatus according to claim 41, wherein said support means includes an intake duct having an intake port which is open downward and disposed in such a manner as to surround said processing head.

45. A plasma film forming apparatus according to claim 1, wherein said processing head includes a member to be faced with said base material, said base material opposing member includes a blowoff region where said first and second gas blowoff passages are disposed and an expanding region expanded from said blowoff region thereby to gain a ratio for forming a film, and said expanding region is connected with an inert gas introduction means; and

said expanding region of said base material opposing member is composed of a material having such a degree of gas permeability that the inert gas coming from said gas introduction means is allowed to permeate toward a base material opposing surface and the degree of permeation and thus the degree of oozing of said inert gas from said base material opposing surface is such that said processing gas can be prevented from contacting said base material opposing surface without disturbing a flow of said processing gas.

46. A plasma film forming apparatus according to claim 45, wherein said gas permeating material is porous.

47. A plasma film forming apparatus according to claim 45, wherein said gas permeating material is a porous ceramic.

48. A plasma film forming apparatus according to claim 45, wherein a groove for temporarily storing therein the inert gas coming from said gas introduction means is formed in an opposite side surface to said base material opposing surface in said expanding region of said base material opposing member in such a manner as to be recessed toward said base material opposing surface.

49. A plasma film forming apparatus according to claim 48, wherein said base material opposing member has a short direction and a longitudinal direction, each of said regions extends in the longitudinal direction, said expanding region is provided at both sides in the short direction with a blowoff region sandwiched therebetween, and said groove is formed in each expanding direction in such a manner as to extend in the longitudinal direction.

50. A plasma film forming apparatus according to claim 48, wherein said base material opposing member is entirely integrally formed from a gas permeating material, and a gas permeation prohibiting member for prohibiting gas permeation is disposed at an inner side surface facing with said blowoff region of said groove.

51. A plasma film forming apparatus according to claim 48, wherein said groove is provided at an intermediate part thereof in a direction of the depth with a partition, said partition has a sufficiently higher gas permeability than said gas permeating material, and said groove is partitioned into an upper-stage groove part continuous with said inert gas introduction means and a lower-stage groove part near said base material

opposing surface through said partition.

52. A plasma film forming apparatus according to claim 1, wherein a downstream end of said first flow passage is crossed with a downstream end of said second flow passage, and said crossing part serves as a common blowoff port of said first and second gases.

53. A plasma film forming apparatus according to claim 52, wherein said first and second flow passages are crossed with each other at an acute angle.

54. A plasma film forming apparatus according to claim 53, wherein said processing head includes a surface where said blowoff port is open and which is faced with said base material, and

one of said first and second flow passages is orthogonal to said base material opposing surface, and the other is slantwise to said base material opposing surface and crossed with said one flow passage at an acute angle.

55. A plasma film forming apparatus according to claim 52, wherein said first and second flow passages are arranged such that one of said first and second flow passages is disposed in such a manner as to sandwich or surround the other with said other flow passage sandwiched therebetween, and said one flow passage is approached to the other toward said downstream end and crossed with each other at said blowoff port.

56. A plasma film forming apparatus according to claim 52, wherein said processing head is provided with two each of said electric field impressing electrodes and said ground electrodes, said two electric field impressing electrodes are disposed at said first flow passage in such a

manner as to be faced with each other, one each of said electric field impressing electrodes is faced with one each of said ground electrodes with said second flow passage formed therebetween, said two second flow passages are arranged in such a manner as to be approached to said first flow passage toward said downstream end with one of said first flow passages sandwiched therebetween, and three of those passages are crossed with one another at said blowoff port.

57. A plasma film forming apparatus according to claim 56, wherein said processing head includes a surface where said blowoff port is open and which is to be faced with said base material;

said first flow passage between said two electric field impressing electrodes is orthogonal to said base material opposing surface, each of said two electric field impressing electrodes includes a first surface located on the reverse side to the side which is faced with said first flow passage and slantwise with respect to said base material opposing surface; and

each of said two ground electrodes includes a second surface which is faced in parallel with said first surface of the corresponding electric field impressing electrode and forming said second flow passage therebetween.

58. A plasma film forming apparatus according to claim 6 or 57, wherein said two second flow passages are symmetrical with each other with said first flow passage sandwiched therebetween.

59. A plasma film forming apparatus according to claim 14 or 54, wherein said ground electrode includes said base material opposing surface.